Use of Industrial Excess Heat in District Heating

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Introduction to Excess Heat

Part I - Excess Heat: what it is, why it is used and how

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What is Excess Heat?

Excess Heat (EH) is the heat generated by any thermodynamic process whose main objective is manufacturing products or providing services, and which is released in the environment as a by-product.

Typical industrial processes that produce excess heat:

- Production: refineries, metallurgy, chemical industry, manufacturing …
- Services: data centres, laundries, cold stores, water management, …
- Waste Disposal: waste incineration, closing material cycles, …
- Energy Conversion: condensation power plants, hydrogen electrolysis, …

How is Excess Heat used?

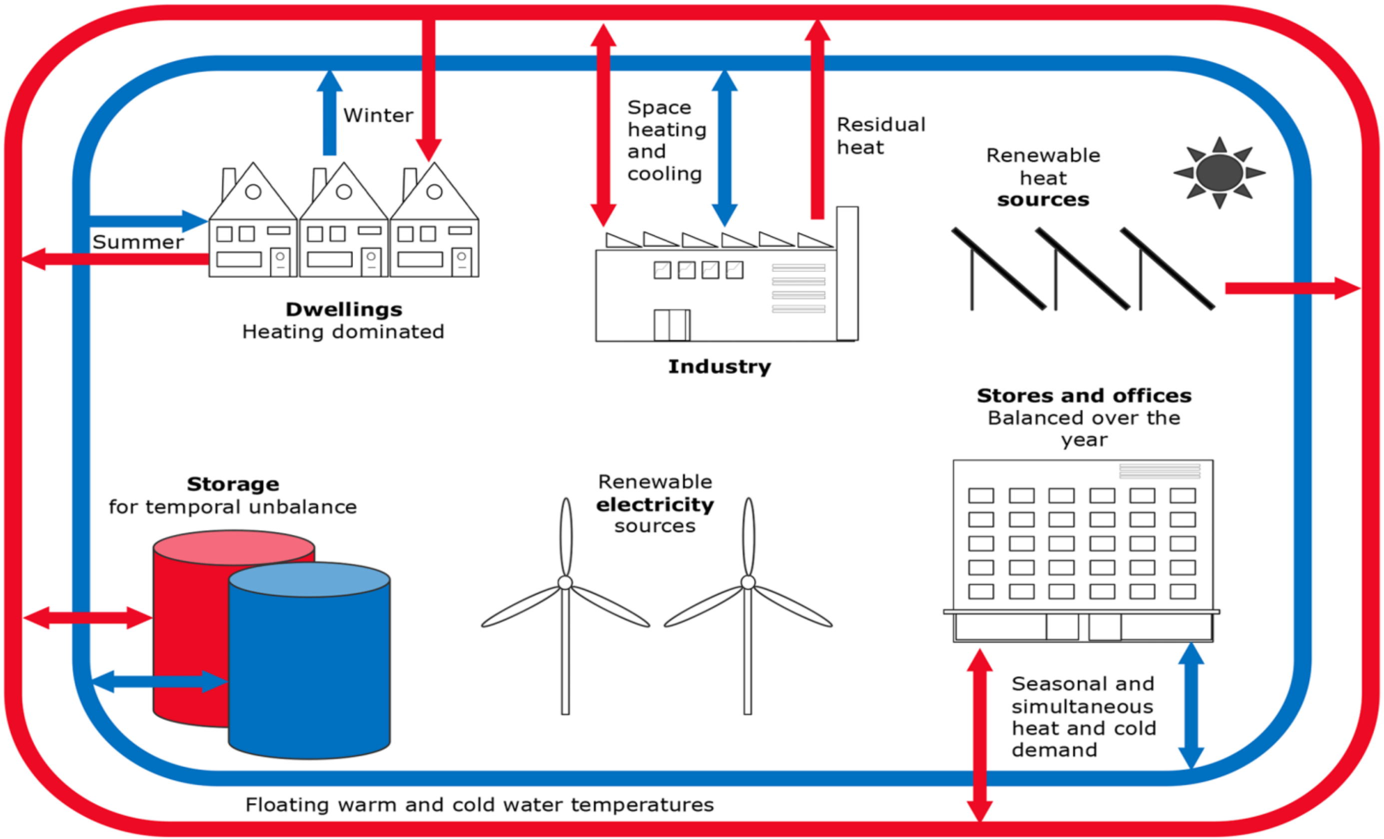
Space Heating (**Cooling**, less common, but on the rise)
- District networks + pressure/pumping system
- Additional Heat pumps for low-temperature
- Heat storage and backup capacity to address fluctuations

Process Heating (Cooling)
- Internal network and pumping system

Benefits: increased energy efficiency and decarbonization, additional income/reduced disposal costs for the industry, improved public image, unbundling of consumers' heating price from market price

Challenges: needs accurate planning, detailed heat supply contracts, high coordination and substantial infrastructure investments

District Heating and Cooling (DHC) – Space Heating



Best Practices:
Common heat sources and uses

Part I - Excess Heat: what it is, why it is used and how

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Common Excess Heatsources

- Refineries, Waste Incinerators
- Power Plants
- Metal Industries
- Pulp and Paper (Chemical) Industries
- Cement/Ceramic Industries
- Agri-food Industries (Bakeries, …)

COMMON / WIDESPREAD

- Wastewater Treatment
- Data Centres
- Other Industries (Textile, Agrifood)
- Subways

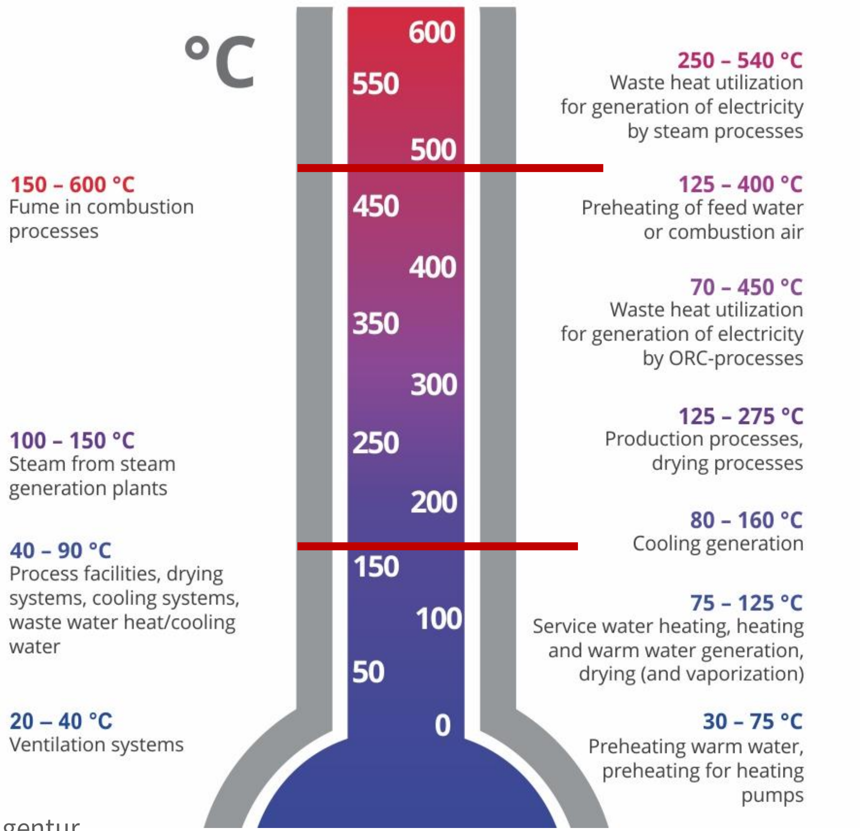
LESS COMMON

Common EH Temperatures

Metals & Glass Furnaces
Waste Incinerators
Refineries

Power Plants (Gas & Steam Turbines)
Ceramic & Cement

Pulp & Paper
Agrifood
Textile
Data Centers
Wastewater
Subways



HIGH

MEDIUM

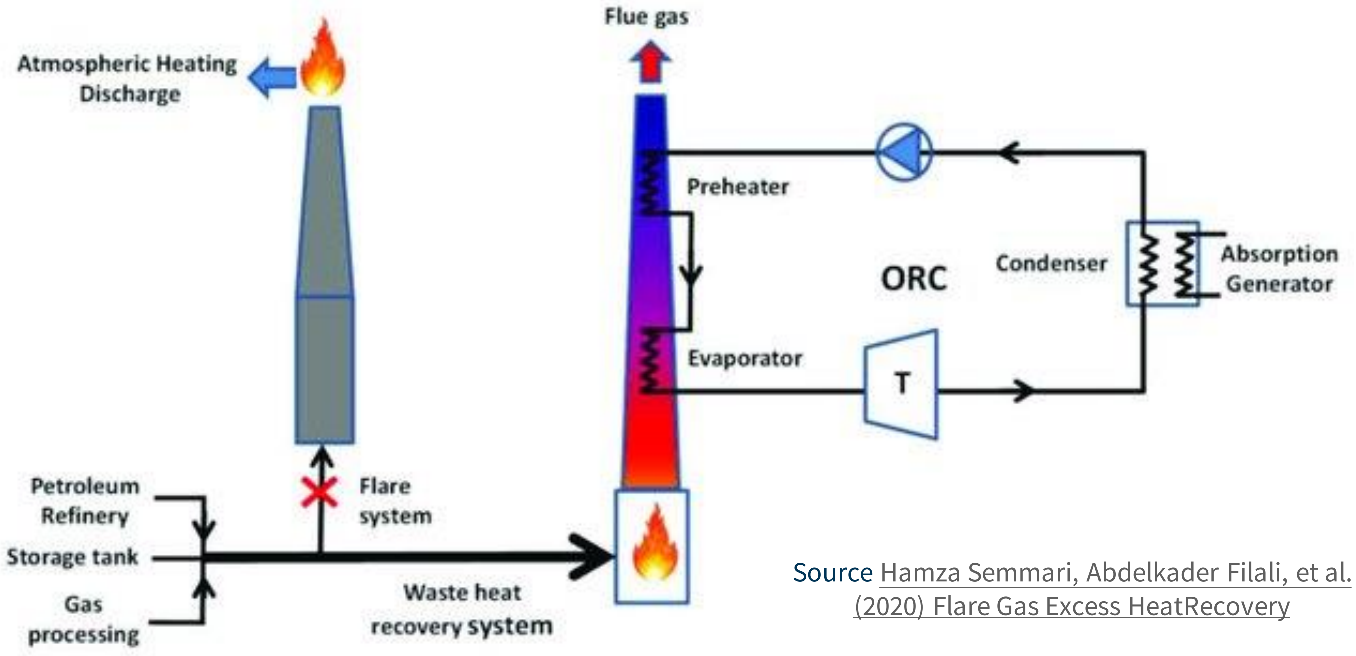
LOW

Source: Deutsche Energie-Agentur

O&G Refineries, Waste Incinerators

Excess Heat recovery from flue gas of:

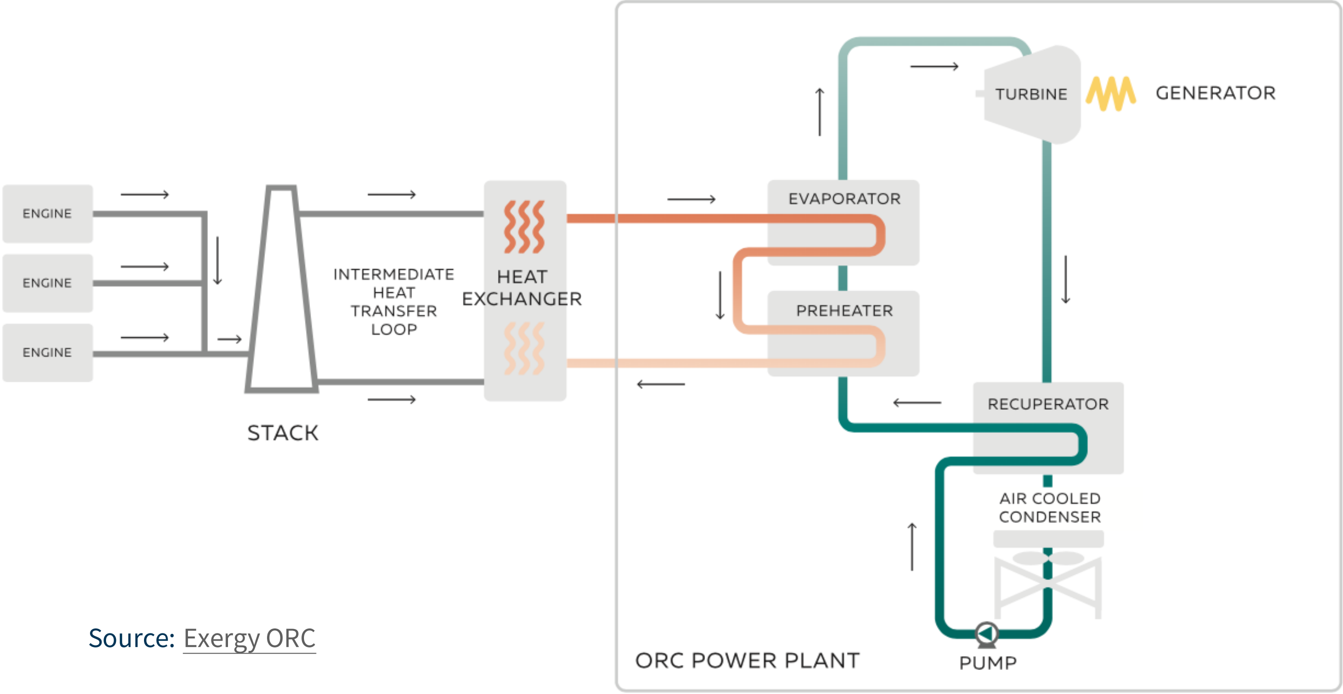
- Fired heaters, steam boilers 14MW from a 100kbbl/day, 150-1200°
- Incineration stack 600-1200°(Vienna: 6MW, 400GWh/y)



Source Hamza Semmari, Abdelkader Filali, et al. (2020) Flare Gas Excess HeatRecovery

Power Plants

Excess Heat recovered from flue gas of turbines and steam condenser (150°-1200°, 10-30MW, average supercritical coal plant)



Source: Exergy ORC

Metal Industries

Project cost:

4-36M€

Capacity:

3-120MW

EH recovered:

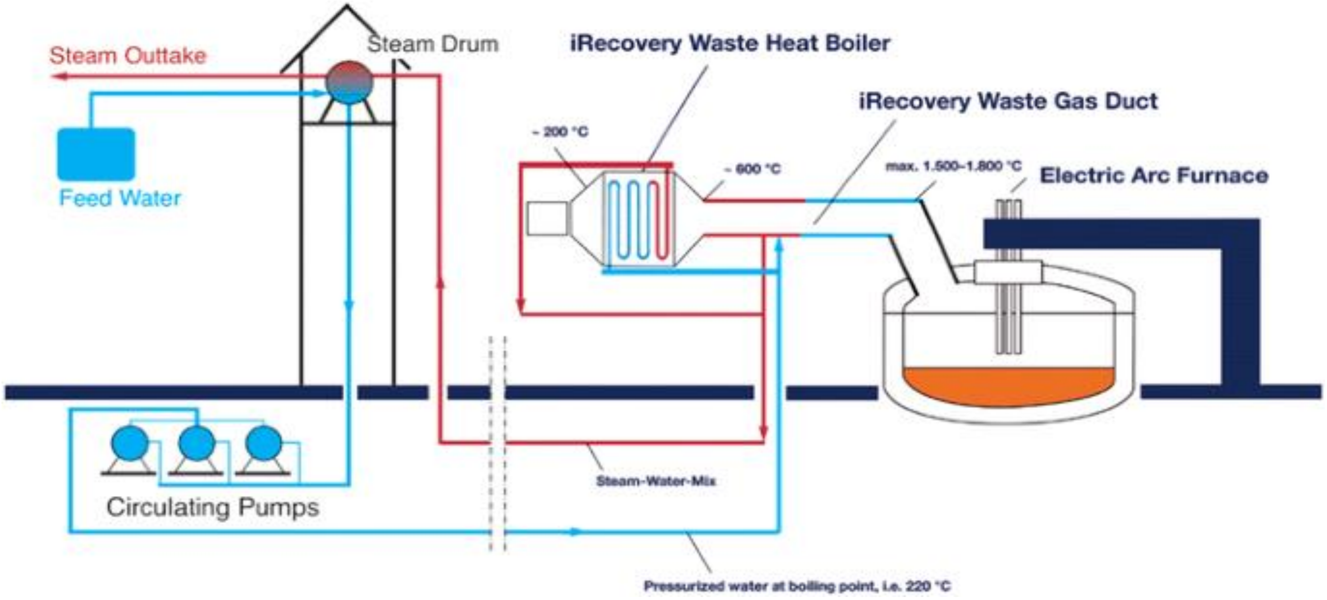
1-250 GWh/y

DH Network size:

1-500 km

Distance: 2-8km

EH temperature: up to 200-1200°



Source: Lifeng Zhang, Excess HeatRecovery from Metal Industries

Examples: Thyssenkrupp AG (Duisburg/ Dinslaken), Arcelor Mittal (Saint Chely d'Apcher, Dunquirque)

Pulp and Paper (Chemical) Industries

Project cost: 4-23M€

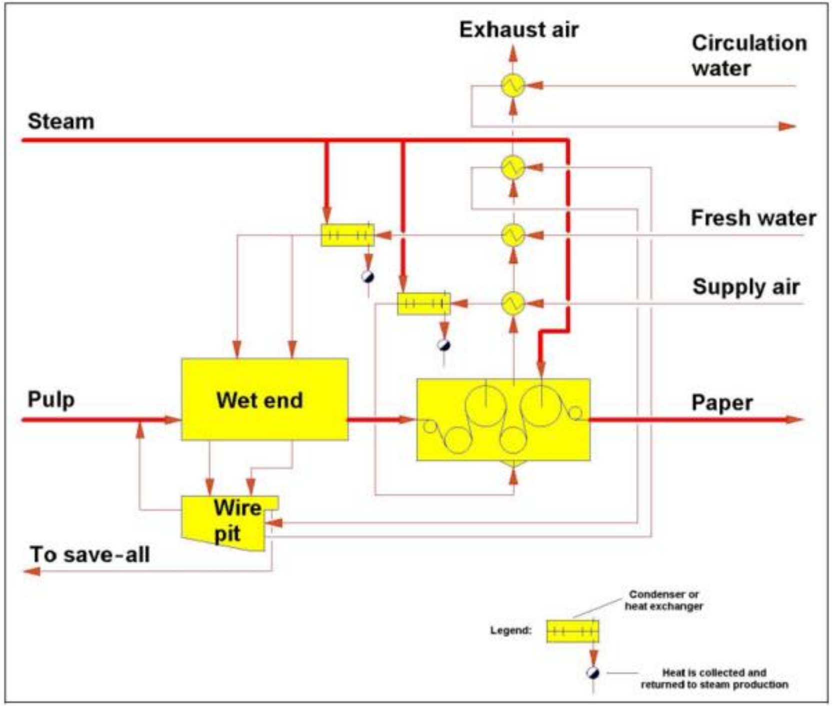
Capacity: 2-35MW

EH recovery:
5-175 GWh/y

DH Network size: 7-1200 km
Distance: 1-7 km from plant

EH temperature: 150-400° from vessels containing pulp, from flue gases of boilers, from sewage water and pulp drying

Examples: Zellstoff Pöls AG (Aichfeld, Austria)



Source: Paper Machine Heat Recovery

Cement Industries

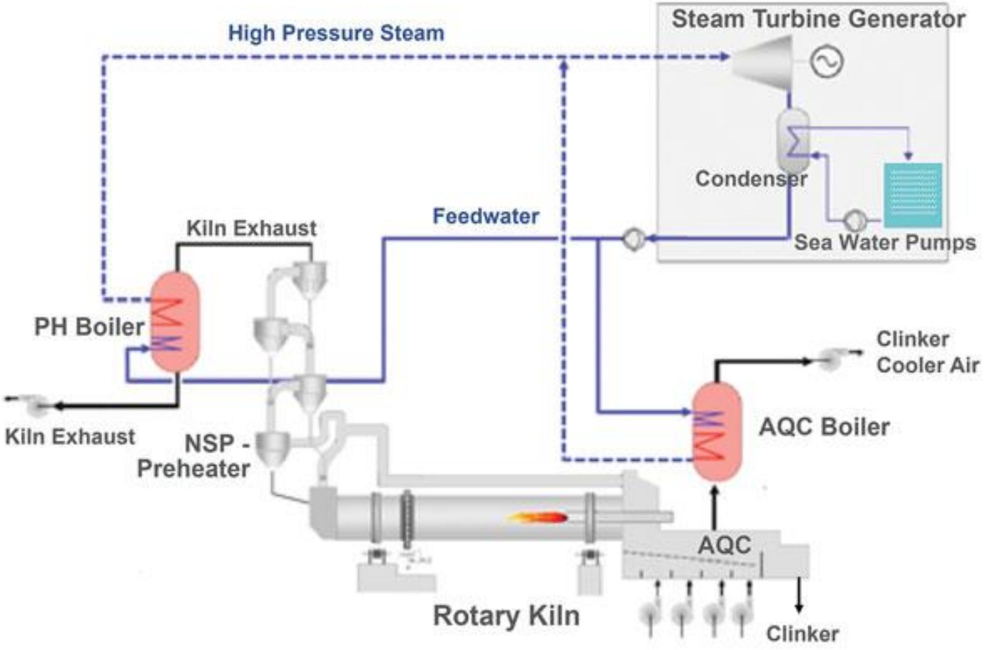
Project cost: 1-5M€
Capacity: 4-5MW

EH after internal recovery:
4-22 GWh/y

DH Network size: 4-22 km

Distance: 1.5-2km from plant
EH temperature: 300-350°

Examples: Kirchdorfer Zementwerk Hofmann, Zementwerk Hatschek, Lafarge Zementwerk Retznei (Austria)



Source: WHR in a Cement Plant, The international Cement Review

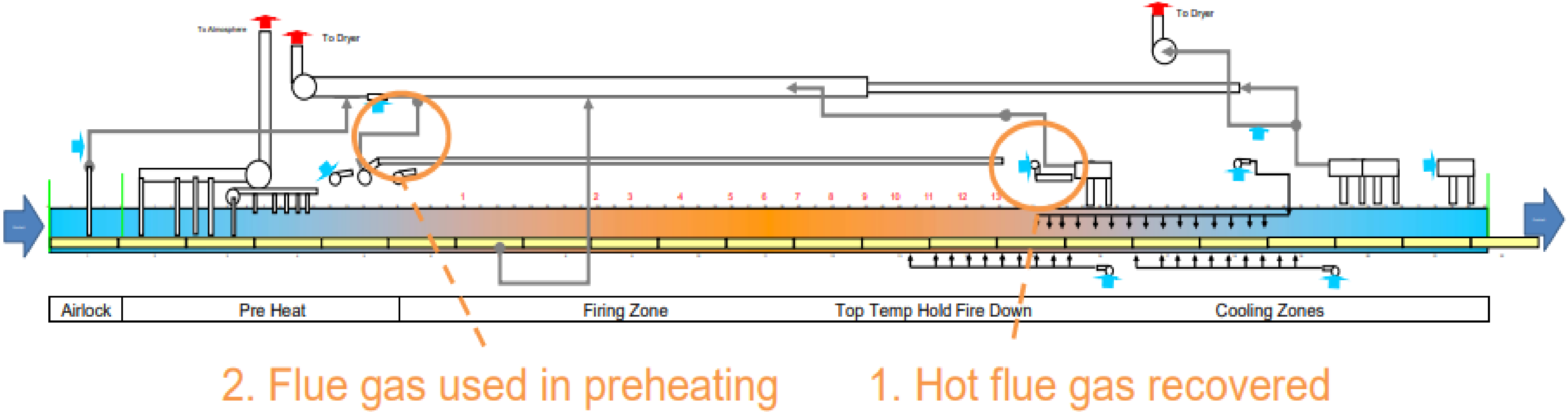
Ceramic Industries

Common heat recovery (150-200°) from roller kilns (750-1800°):

- Self-consumption for spray drying and drying phase
- CHP turbine/generator (~3-5MW) saving 10-50% of heat input

Additional heat recovery from firing roller kiln(s):

- KPM Porcelain - Vattenfall urban DHC, Berlin (110°- 1MWh/y)

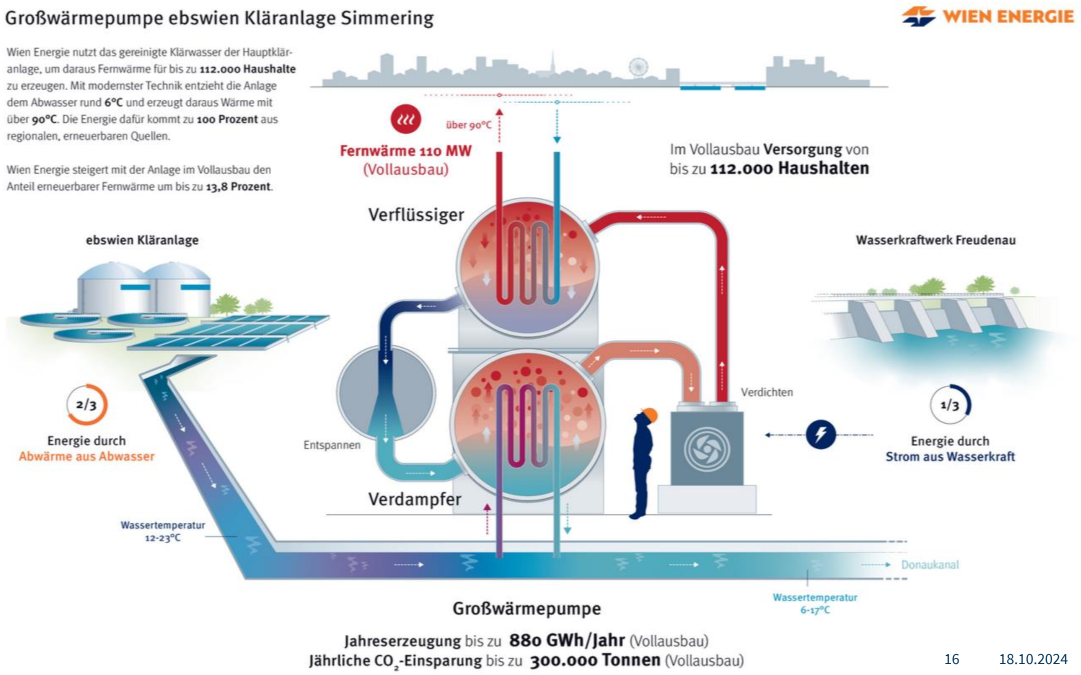


Source: Weinerberger and Ceramics Federation, The potential for recovering and using surplus heat from industry

Wastewater after treatment

Implementation example:

- 110 MWt at full capacity with over 90°C flow temperature
- 70 MEUR Investment
- Delta T: ~20-5°C
- 2/3 of energy by waste heat from waste water
- Production: 880 GWh/year



Source: Wien Energie

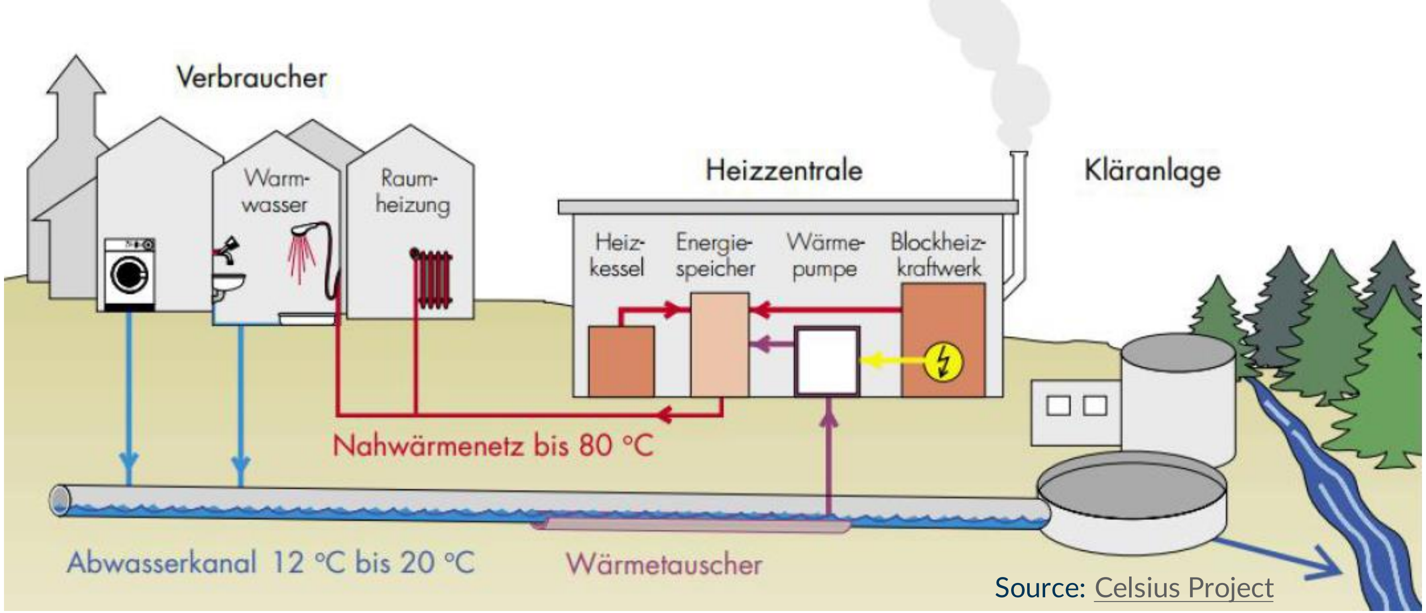
Wastewater before treatment

Example:

Capacity: 243 kW heating - 200 kW cooling (Singen)

Heat pump COP: 3.9 (Singen) Temperatures: ~15°C.

Period: since 2004 (Singen) - GVV Städtische Wohnbaugesellschaft mbH



Source: Celsius Project

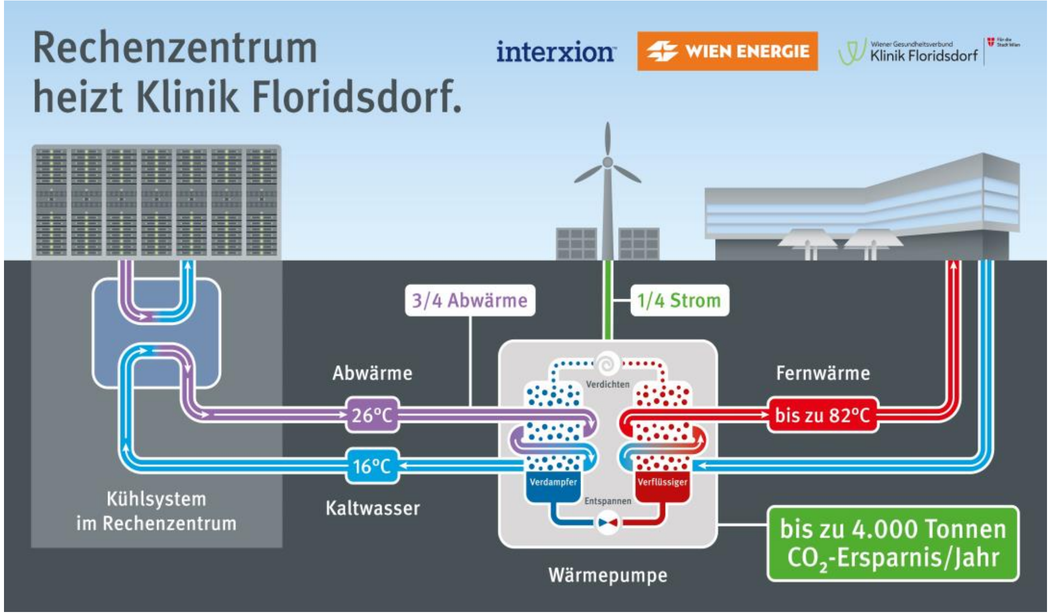
Datacenters

Implementation example:

- 3.5 million € investment

(incl. support from the government)

- Approx. 120,000 servers
- Realization: mid-2023
- Delta T = 10°C
- Total of 3 HP:
- Heating capacity: 3 MWth
- Cooling capacity: 2.1 MW
- Flow: up to 82°C
- ¼ renewable electricity
- 3/4 of the energy by Excess Heatfrom the data center.
- Examples: Val d'Europe (FR), Mäntsälä (FL)



Source: Wien Energie

Agri-Food Industries

Project cost: 0.5-19M€

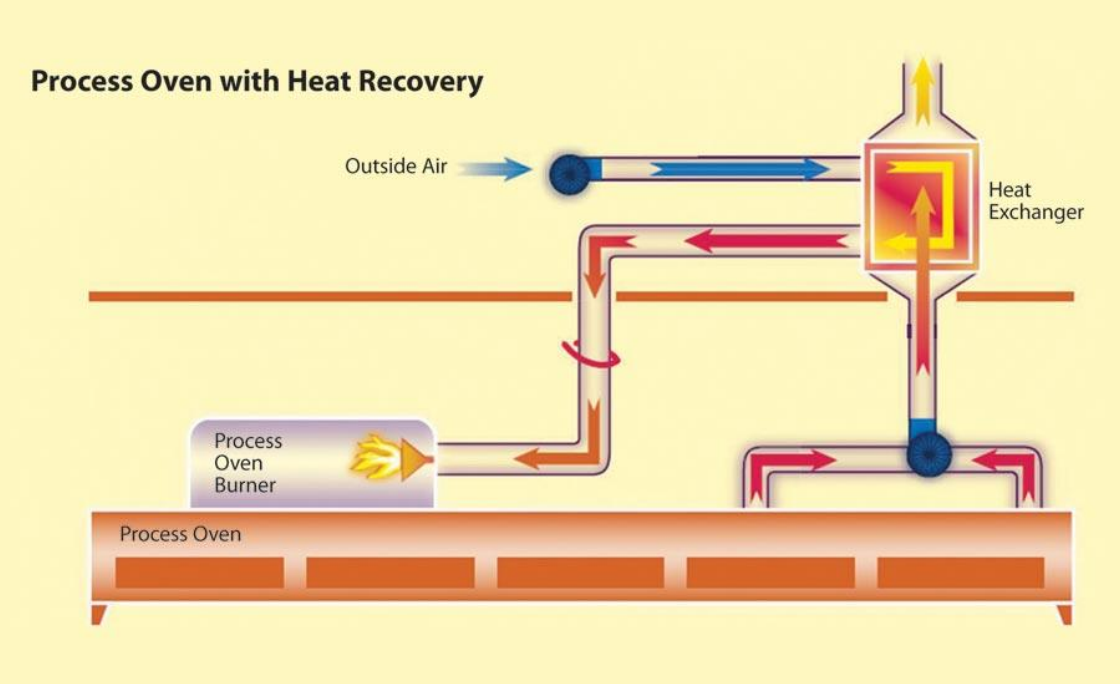
Capacity: 0.5-5MW

EH: 2-20 GWh/y

DH Network size: 3-30 km
Distance: up to 8km

EH temperature: 100-250°from flue gases of baking ovens, 20-50° from breweries, distilleries and milk pasteurization

Examples: Manner, Meyer Waffel, Breweries (Puntigamer, Leoben), Tirol Milch



Source: Process Heating, Heat Recovery for Process Efficiency

Texile/Laundry Industries

Project cost: 1M€

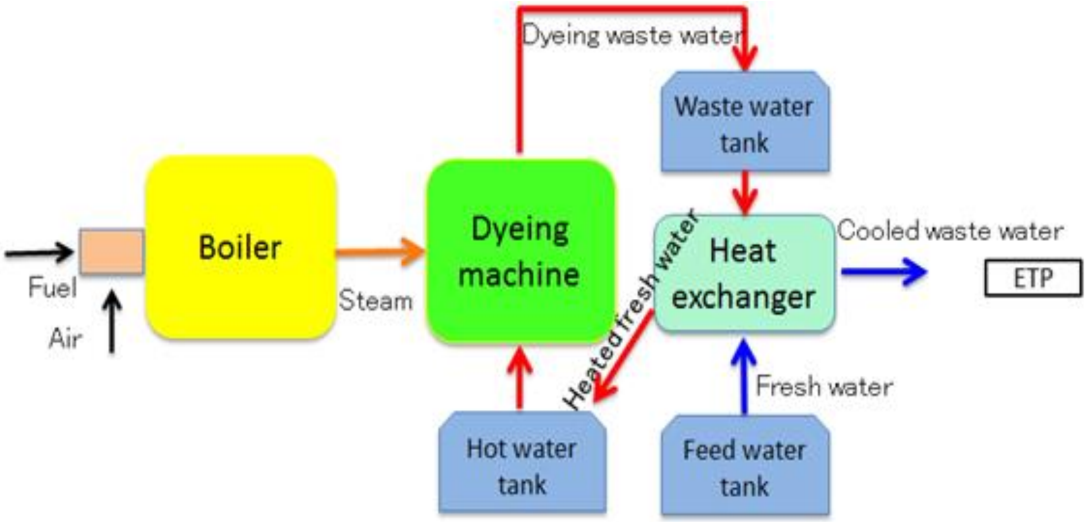
Capacity: 0.5-1MW

WH: 4 GWh/y

DH Network size: 1 km

EH temperature: 60-90° from exhaust hot water (washing machines, dyeing process) and steam (dryers)

Examples: Getzner Textil (Bludenz)



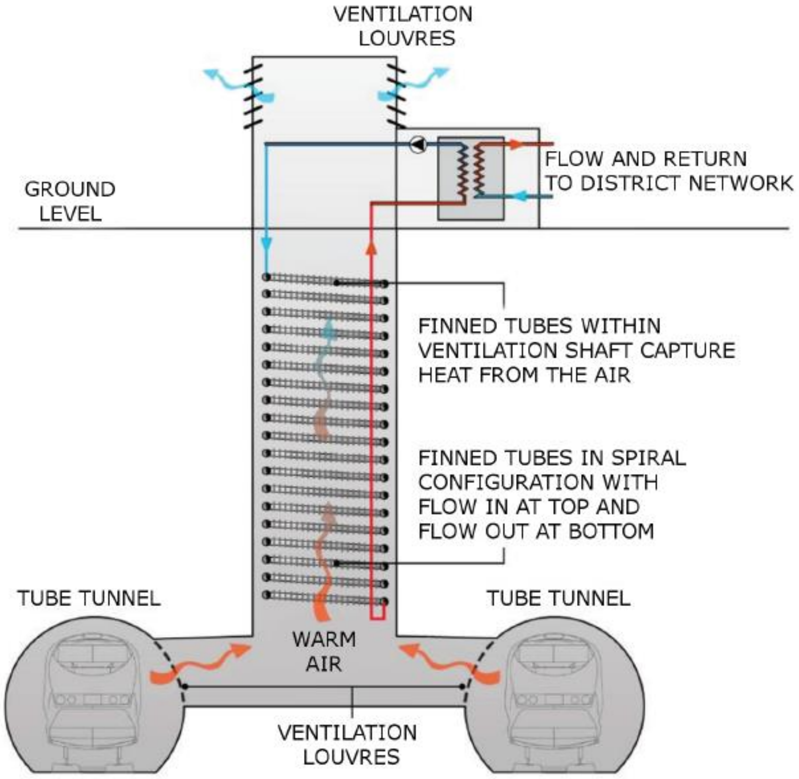
Source: Excess HeatRecovery and Utilization in Textile and Garment Factories

Subways

Temperature:
10-30°
(winter / summer)

Capacity: 1MW

Examples: London, Turin, Vienna, …



Source: Celsius Project

Excess Heat Cadasters: sources mapping, registry set-up, and examples of existing ones

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Excess Heat Cadasters

Purpose: mapping sources, raise awareness, provide data

Heat sources are identified by:

- Location
- Temperature level: low/medium/high
- Heat flow: water/fumes (GWh)
- Fluctuations: daily, weekly and annual

Exploitability is assessed in function of:

- Heat demand in the heat sink
- Proximity to the heat sinks -> cost of transport
- Costs of heat extraction
- Existence of generation and grid infrastructures

Set up an Excess Heat Cadaster

Steps:

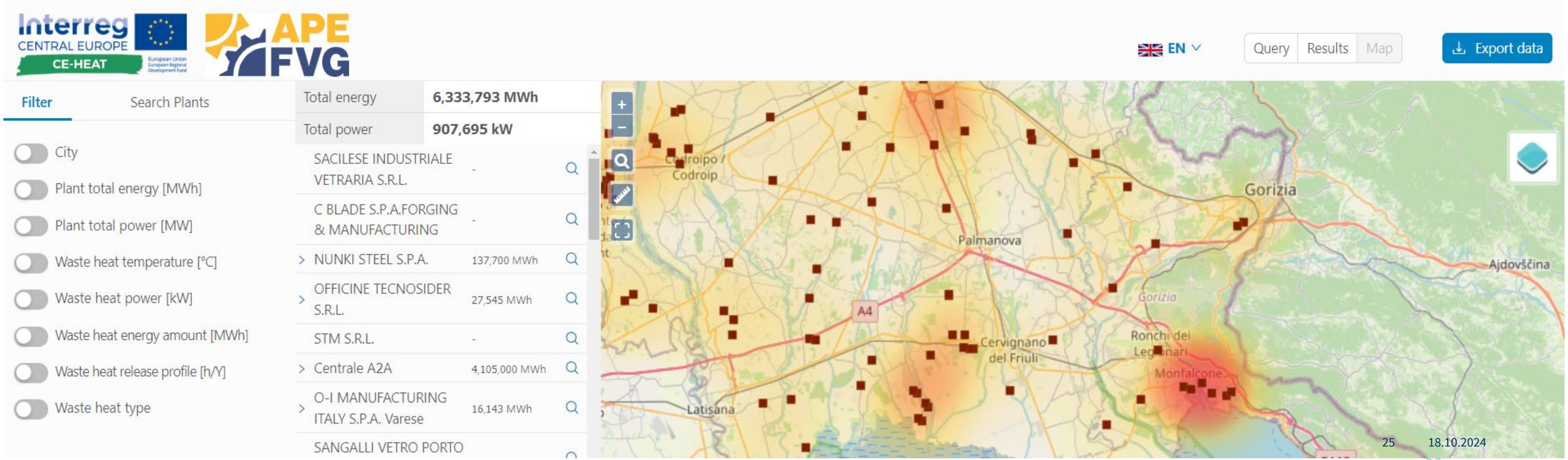
- Identify potential EH sources: by sector (NACE codes)
- Estimate data: conversion tables for subsector and production
- Contact sites and confirm via surveys/interviews

Useful documents:

- Manual for Excess HeatCadaster Development
- Data Collection Survey

Existing Excess HeatCadasters

- Styria Digital Atlas & Excess HeatRegistry
- Bavaria Excess HeatCadaster
- Interreg CE-HEAT Excess HeatPotential: United Kingdom, Slovenia, Croatia, Burgenland (Austria), Thuringia (Germany), Czech Republic, Lower Silesia (Poland), Friuli Venezia Giulia (Italy)



Excess Heat:
Challenges & Factors of success

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Common Challenges

- **Lack of data** --> Excess HeatCadasters can provide a starting point
- **Lack of interest** from industries in participating in EH recovery projects
  - Economy -> heat supply can be paid to the EH source
  - Motivation -> Energy Industries can be subject to emission targets
- Industrial EH suppliers and Network Managers/Heat Suppliers usually have **different priorities** (reduce costs vs security of supply) and amortization periods (short for industry, long for heat supplier)
- **Misaligned** heat **load profiles** of supply and demand (daily/seasonal)
- **Default Risk**: the industry shuts down/relocates -> Backup capacity
- Managing temporal fluctuations -> Heat Storage, back-up capacities

Success Factors

- **Spatial proximity** of heat source/sinks reduces connection costs.
- The better the **profile** of the heat **source matches** the **profile** of the heat **sink** and the higher the **current heat supply costs** of systems to be replaced, the better.
- The more **constant and** the **higher** the **temperature**, the more valuable and better suited the Excess Heatis for recovery and use.
- **Accurate contract negotiations** between EH supplier, system heat supplier and customers.

Discussion - Q&A

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Hotmaps:
EH Layers, CM Add Industry Plant, CM Excess Heat Transport Potential

Part II - Assess Excess Heat potential exploitation

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Hotmaps: visualise Excess Heat

HOTMAPS is an open-access tool that allows public authorities to identify, analyse, model and map resources and solutions to start heating and cooling planning in their territory in a resource- and cost-efficient way.

Excess Heat Potentials

- **Industrial Sites Excess Heat**(layer of default database)
- **CM Add Industry Plant** (to upload own data)
  Add industrial sites not mapped in the default database with their heating and cooling demand and Excess Heat potential through a stand-alone Excel form.

Hotmaps: visualise Heat Density

Heat Demand

- **Visualize Heat Density Map** default layer/(upload own data)

Assessment

- **CM Excess Heat Transport Potential**
  Calculate the flow and costs of heat transmission from potential Excess Heatsources to potential district heating areas.
  - Thresholds data for Calculate DH potential within a selected region:
  1) Minimum heat demand per hectare, 2) Minimum heat demand in the DH area.
  - Extra inputs: Industrial Site Subsector and Excess Heat

Hotmaps: Practical Exercise (1/2)

1. Connect to the Hotmaps Toolbox: https://www.hotmaps.eu/map
2. Create a User Account (click on Connect, on the top left)
3. Activate your account by clicking on the link in the email you received.
4. Search a location with the search bar (top left)
5. Select the Industrial sites excess heat layer and click to visualize (low, medium, high excess heat)
6. Identify an area with significant heat demand near the industrial site and select it with the polygon at the hectare level.
7. Close the Industrial excess heat layer
8. Click Load the results to visualize them (Heat Demand Total/Res/Non-Res)
9. Open the Calculation Modules menu and scroll to **CM Add Industry Plant.**

Hotmaps: Practical Exercise (2/2)

10. **CM Add industry plant:** click on the wiki link to download the Excel file
11. Populate the general info for a nearby industry, then choose an option:
    - If you know the exact heat demand and supply
    - If you know only the subsector and annual production
    - If the subsector is not listed in option 2
12. Extract the 2 CSV files, access your user account and upload them.
13. Tick the 2 layers now in the list: the newly added plant is visualized on the map, with a circle for Excess Heat potential and a triangle for the subsector
14. **CM Excess Heat Transport Potential:** scroll down and select to use the two layers just uploaded, then toggle the transmission line threshold as preferred. Run CM and assess results.
15. If any potential area is found, it is coloured on the map, otherwise, lower the parameters until you find a potential DH area.

THERMOS and EMB3Rs Demo

Part II - Assess Excess Heat potential exploitation

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Other Tools: EMB3Rs, THERMOS

THERMOS is a free, web-based **DHC planning software** that analyses **network options including paths, load anchors and connection to single additional buildings** for the deployment of new and upgrade/expansion of existing DHC systems.

EMB3RS is a free web-based **matching-tool** that evaluates the **compatibility of Excess Heat and cold sources and sinks** in industrial processes, energy systems and District Heating and Cooling (DHC), based on the simulation of technical and economic supply-demand scenarios.

Discussion – Q&A

Part II - Assess Excess Heat potential exploitation

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Thank you for your attention!

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